02-15-00

Docket No. 14XZ00055

UTILITY PATENT APPLICATION TRANSMITTAL

TO: Box PATENT APPLICATION
Assistant Commissioner for Patents
Washington, DC 20231

Transmitted herewith for filing under 35 USC 111(a) and 37 CFR 1.53(b) and 35 USC 371 is a new ☒ utility ☐ design patent application for an invention entitled:

METHOD FOR REDUCING NOISE IN X-RAY IMAGES

and invented by: Vladislav BOUTENKO and Thierry LEBIHEN

If a continuation application:

☐ continuation ☐ division ☐ continuation-in-part
of prior application Serial No.

Enclosed are:

1. ☒ Specification having eight pages (8) comprising the following:
   - a. ☒ Claims numbered from 1 to 3
   - b. ☒ Abstract of the Disclosure
   - c. ☒ Drawing (s) as follows:
     - (1) ☐ Formal ☒ Informal
     - (2) Number of Sheets – two (1) with Figures No. 1-2
   - d. ☒ Oath or Declaration as follows:
     - (1) ☐ Original and signed
     - (2) ☒ Unsigned
     - (3) ☐ Copy from prior application Serial No. filed
     - (4) ☒ With Power of Attorney
     - (5) ☐ Without Power of Attorney
2. ☐ Incorporation by Reference (if Box 1d(3) is checked)
3. ☐ Assignment
   - ☐ Recordation Cover Sheet
   - ☐ Document

4. ☐ Preliminary Amendment

5. ☒ Acknowledgment Postcard

6. ☒ Certificate of Mailing by "Express Mail"

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 as Express Mail No. EK552819899US on February , 2000 and is addressed to the Assistant Commissioner for Patents, Box PATENT APPLICATION, Washington, DC 20231.

Dolores K. Tillson

(Name and Date) Dolores K. Tillson, February 14 2000

7. ☒ Filing fee calculated and transmitted:

a. ☒ as described below for the claims as filed

For	No. Filed	No. Extra	Rate	Small Entity Fee	Rate	Large Entity Fee
Basic				$ 345		$ 690
Total Claims	3 - 20 =	-0-	X $ 9 =	$	x $ 18 =	$
Ind. Claims	1 - 3 =	-0-	X $ 39 =	$	x $ 78 =	$
Mult. Dep. ☐			+$130 =	$	+ $260 =	$
Total Filing Fee				**$ 345**		**$ 690**

b. ☐ see attached PTO-1398 for Transmittal Letter to US Designated/Elected Office for National Stage of PCT

c. ☐ design filing fee of $310.00

d. ☒ The Commissioner is hereby authorized to charge and credit Deposit Account No. 09-0470 as described below. A duplicate copy of this sheet is enclosed.

(1) ☒ Charge the amount of ☐ $310.00 ☒ $690.00 ☐ .00 as filing fee.

(2) ☒ Credit any overpayment.

(3) ☒ Charge any additional filing fees required under 37 CFR 1.16 and 1.17.

(4) ☐ Charge the Issue Fee set in 37 CFR 1.18 at the mailing of the Notice of Allowance, pursuant to 37 CFR 1.311(b).

d. ☐ A check in the amount of $ to cover the filing fee is enclosed.

8. ☒ Information Disclosure Statement

a ☒ PTO-1449

b. ☒ Copies of Cited Documents

9. ☒ Certified Copy of Priority Document

Country	France
Filing Date	18 February 1999
Application No.	99 02032
Applicant	GE Medical Systems S.A.

10. ☐ Verified Statement to establish Small Entity status under 37 CFR 1.9 and 37 CFR 1.27

11. ☐ Additional Enclosures as follows:

a. ☐

b. ☐

Date: February 14, 2000

Jay L. Chaskin
Reg. No. 24030

General Electric Company
3135 Easton Turnpike - W3C
Fairfield, CT 06431

Tel: 203-373-2867
Fax: 203-373-3991

METHOD FOR REDUCING X-RAY NOISE

BACKGROUND OF THE INVENTION

The invention concerns the fluoroscopy and, in particular, the treatment of a sequence of fluoroscopic images of a body, particularly of a human body.

The invention further applies, in particular, to cardiac fluoroscopy.

By comparison with radiography in acquisition mode, where the X-ray doses are greater, in order to obtain better quality registered images for diagnostic purposes, fluoroscopy is carried out with weaker X-ray doses and is, in particular, used in the surgical field, for example, to position coronary endoprostheses ("stent" in English) by means of catheters.

In fluoroscopy the movement of the objects of interest, like, for example, coronary endoprostheses, as well as, notably, in cardiac fluoroscopy, the background movement, associated linked, for example, with the patient's respiration, as well as with the movements of the table on which the patient is placed, produce disturbances in the images, to which is added noise, particularly of electrical origin. That noise is all the more disturbing, the longer the fluoroscopic examination lasts, typically about 45 minutes, in order to position an intravascular prosthesis correctly, and produces, consequently, a visual inconvenience for the physician.

In the presence of immobile images, the noise could easily be eliminated by simple temporal filtering. However, in fluoroscopy mobile images are present, which are translated, if a filtering of images (for example, a filtering by temporal means) is simply carried out, by a blurred movement or else a loss of contrast of the mobile objects (depending on the size of the objects). In other words, there is then no difference between the arrival and departure of an object of interest and a noise peak.

At present, the standard algorithms of image processing in fluoroscopy resort to a criterion of distinction between a variation due to noise and a variation due to movement. The filtering treatment is then stopped or diminished in the presence of a movement. However, the cessation of filtering produces a recurrence of the noise, which is translated on the images by noise trails behind the mobile objects.

BRIEF DESCRIPTION OF THE INVENTION

The invention is intended to offer a more satisfactory solution to these problems.

The invention therefore proposes a method of treatment of a sequence of fluoroscopic images of a body, comprising the acquisition of a sequence of images, the elaboration for each acquired current image of a current filtered image from the acquired current image and preceding filtered image, and visualization of the sequence of filtered images.

According to a general characteristic of the invention, for each acquired current image, the displacement of said current image is determined in relation to the preceding image acquired in the image acquisition plane, a so-called "displaced" preceding filtered image is elaborated, by spatially displacing the preceding filtered image, taking said displacement into account, and the current filtered image is elaborated by the weighted average between the acquired current image and the displaced preceding filtered image, so as to improve the quality of the images visualized.

When the body is laid on a movable table, the displacement of said current image is advantageously determined in the plane of acquisition of the images from the displacement value of the table, the spatial orientation of the plane of acquisition relative to the table and the distance of that plane of acquisition relative to the table.

As a variant, one can also determine the displacement of said current image in the plane of acquisition of the images from the content of those acquired images.

BRIEF DESCRIPTION OF THE DRAWINGS

- Figure 1 schematically illustrates a system making possible a use of the method according to an embodiment of the invention; and

- Figure 2 schematically illustrates two successive acquired images.

DETAILED DESCRIPTION OF THE INVENTION

In Figure 1, reference TB designates a table translatable in two orthogonal directions Fx and Fy by means of a crank, for example, not represented here for purposes of simplification. Displacement sensors CDx and CDy, of construction known per se, make it possible to determine the values of the displacements in directions Fx and Fy respectively and deliver that information to treatment means MT containing a microprocessor.

On the table TB, a patient CP is stretched out and undergoes a fluoroscopy examination. In that regard, the fluoroscopy apparatus contains an X-ray source S emitting X-rays along an axis Ax in the direction of a detector DC of standard con-struction known per se, also connected to the treatment means MT. The detector DC is a plane detector, forming the image acquisition plane. This plane is perpendicular to axis Ax. The detector DC and the source S form part of an apparatus containing an arm moving in space around the patient CP.

The orientation of the axis Ax is known perfectly at every moment, as is the distance between the table TB and the detector DC. The displacements in directions Fx and Fy of the table TB can therefore be easily converted in a standard manner known per se into displacements u and v in the plane of the detector DC, that is, in the image acquisition plane.

Reference is now made, in particular, to Figure 2. It can be seen that, on fluoroscopy examination, a sequence of images X_n is acquired, typically at the rate of 30 images per second. The pixel values of each image are stored, as they are acquired, in a memory of treatment means MT, in order to permit image processing and, in particular, their filtering.

This being so, when in the course of the fluoroscopy examination the physician moves the table TB and/or the coronary endoprosthesis so as to keep the region of the body considered in the field of X-radiation, the object of interest (for example, the coronary endoprosthesis), which is very schematically represented under reference A in the image X_n, is moved from the displacement vector D into the following image X_{n+1} (PO and POD respectively representing the centers of the prosthesis in both images).

The displacement vector $\vec{D}$ has the coordinates u and v in the image acquisition plane, corresponding to displacement of the table in directions Fx and Fy (it is assumed here that only the table has moved).

The invention provides here for carrying out a filtering treatment by using, on the one hand, the current acquired image X_{n+1} and, on the other, not the preceding filtered image directly corresponding to the preceding acquired image, but a displaced filtered image YD.

More precisely, one implements in the microprocessor recursive law (1):

$$Y_{n+1} = (1-a)X_{n+1} + a\,YD_n \qquad (1)$$

in which Y_{n+1} represents the current filtered image, X_{n+1} the current acquired image, YD_n the preceding filtered image displaced relative to the preceding filtered image Y_n and "a" a weighting coefficient, typically equal to 0.2 (and possibly a function of X_{n+1} and of YD_n).

The law (1) is translated for each pixel of coordinates i,j in the image acquisition plane by law (2):

$$y_{n+1}(i,j) = (1-a)\, x_{n+1}(i,j) + a\, y_n(i-u, j-v) \qquad (2)$$

In other words, for each pixel of coordinates i,j of the acquired current image, the coordinates I,J of the displaced pixel are calculated in the preceding filtered image, taking into account the movement of the table (I = i-u, J = hj-v), and law (2) is applied.

The successive filtered images Y_{n+1} are successively displayed on the means of visualization MV of the fluoroscopy device.

When coordinates I and J are negative, that is, when there is no equivalent in the preceding image for a portion of the outlet image Y_{n+1}, that image portion is darkened. In other words, the values $y_{n+1}(i,j)$ are fixed at zero.

This darkening is not visible, taking into account the frequency of acquisition of the images and the customarily rapid movements of displacement of the table. In practice, it has been observed that this darkening is not visible when it does not exceed 10% of the image for the most rapid displacement movement.

In the mode of use just described, the coordinates u and v are determined from the movement of the table. This being so, it is also possible as a variant to calculate the coordinates u and v of displacement vector D directly between two acquired successive images by standard algorithms of detection of movement, by using, for example, the maximum criterion of correlation between two environments of two homologous pixels.

Materially, the displacement of filtered images is very simply carried out by using the delay elements connected to the lines and columns of the image storage memory.

Various modifications in structure and/or steps and/or function may be made by one skilled in the art without departing from the scope of the invention.

WHAT IS CLAIMED IS:

1. A method of treatment of a sequence of x-ray images of a body, comprising the acquisition of an image sequence, the elaboration for each acquired current image of a current filtered image from the acquired current image and from the preceding filtered image, and visualization of the filtered image sequence, wherein for each acquired current image the displacement of the current image is determined relative to the acquired preceding image in the image acquisition plane, a displaced preceding filtered image is elaborated by spatially displacing the preceding filtered image, taking the displacement into account, and the current filtered image is elaborated by the weighted average between the acquired current image and the displaced preceding filtered image, so as to improve the quality of the images visualized.

2. The method according to claim 1, in which the body is laid on a movable table, wherein the displacement of the current image is determined in the image acquisition plane from the value of displacement of the table and spatial orientation and distance of the acquisition plane relative to the table.

3. The method according to claim 1, wherein the displacement of the current image is determined in the image acquisition plane from the content of the acquired images.

METHOD FOR REDUCING X-RAY NOISE

ABSTRACT OF THE DISCLOSURE

For each acquired current image, the displacement of said current image is determined relative to the acquired preceding image in the image acquisition plane, a displaced preceding filtered image is elaborated by spatially displacing the preceding filtered image, taking said displacement into account, and the current filtered image is elaborated by the weighted average between the acquired current image and the displaced preceding filtered image, so as to improve the quality of the images visualized.

FIG.1

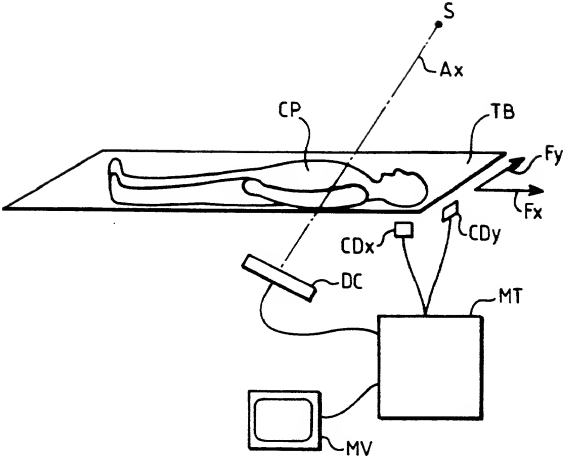
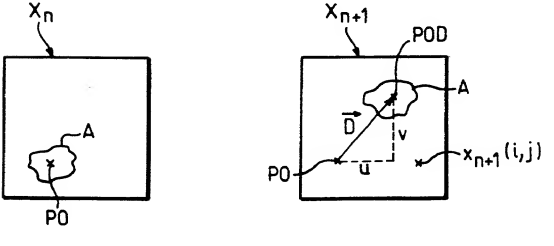


FIG.2



COMBINED DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below-named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD FOR REDUCING NOISE IN X-RAY IMAGES

☐ the specification of which is attached hereto OR

☐ was filed on as Application Serial No. or PCT International Application Number and was amended on (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with 37 CFR §1.56.

I hereby claim foreign priority benefits under 35 U.S.C.§119(a)-(d) or 365(b) of any foreign application for patent or inventor's certificate listed below, and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 37 U.S.C. 119
France	99 02032	18 February 1999	☐ Yes ☐ No
			☐ Yes ☐ No

I hereby claim the benefit under 35 U.S.C. §120 of any United States application(s), or 365(c) of any PCT International application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of 35 U.S.C. §112, I acknowledge the duty to disclose material information as defined in 37 CFR §1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

U.S. PARENT APPLICATION OR PCT PARENT NUMBER	PARENT FILING DATE (day, month, year)	STATUS (patent and number, pending, abandoned)

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s)listed below.

APPLICATION NUMBERS (S)	FILING DATE (day, month, year)

As a named inventor, I hereby appoint Christian G. Cabou (Reg. No. 35,467) and Phyllis Y. Price (Reg. No. 34,234) both of GE Medical Systems, 3000 North Grandview Blvd., Waukesha, Wisconsin 53188; Ronald E. Myrick (Reg. No. 26,315), Henry J. Policinski, (Reg. No. 26,621), and Jay L. Chaskin, (Reg. No. 24,030) all of General Electric Company, 3135 Easton Tumpike, Fairfield, Connecticut 06431-0001 jointly, and each of them severally, my attorneys, with full power of substitution, delegation and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent and Trademark Office connected therewith.

I hereby direct that all correspondence and telephone calls in connection with this application be addressed to Jay L. Chaskin, General Electric Company, 3135 Easton Tumpike, Fairfield, Connecticut 06431-0001, telephone number: 203-373-2867, fax number: 203-373-3991.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that all such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of first sole or joint inventor: Vladislav BOUTENKO

Inventor's signature: _____ Date:_____

Residence: 72, rue Marcel Dassault
92100 Boulogne-Billancourt, France

Citizenship: Russian

Post Office Address: same as residence

Full name of second joint inventor: Thierry LEBIHEN

Inventor's signature: _____ Date: _____

Residence: 45, rue d'Anjou
78000 Versailles, France

Citizenship: France

Post Office Address: same as residence